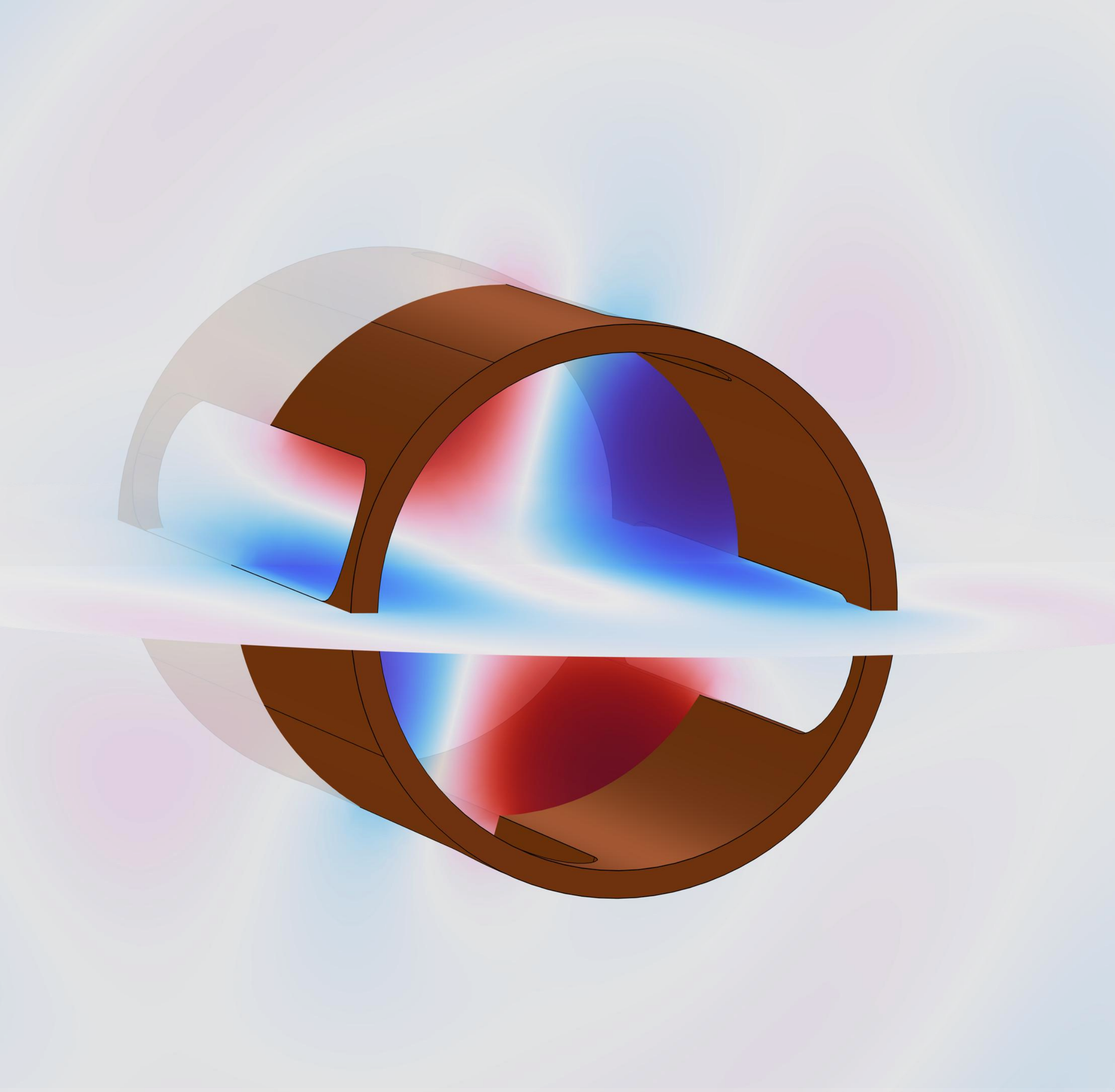




# Nodal-Line Slit-Patterned Open Photoacoustic Cell for Mode Selectivity

A simple passive method for tailoring the modal characteristics of open photoacoustic resonators while retaining the advantages of open-cell operation.

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## Introduction

Photoacoustic spectroscopy (PAS) is a highly sensitive technique for trace-gas detection, in which absorbed modulated converted into an acoustic signal. It has found applications in environmental monitoring, medical diagnostics, and the oil and gas industry.

The acoustic response is strongly influenced by the resonator geometry, which determines resonance enhancement, acoustic losses, and gas-exchange characteristics.

Open photoacoustic resonators enable fast gas exchange, but their increased coupling to the surrounding environment can introduce additional acoustic losses and disturb the modal structure. Here we are investigating a nodal-line slit-patterning concept, where longitudinal slits positioned near the pressure nodes of a selected acoustic eigenmode. This is expected to preserve the targeted resonance while preferentially suppressing the competing modes.

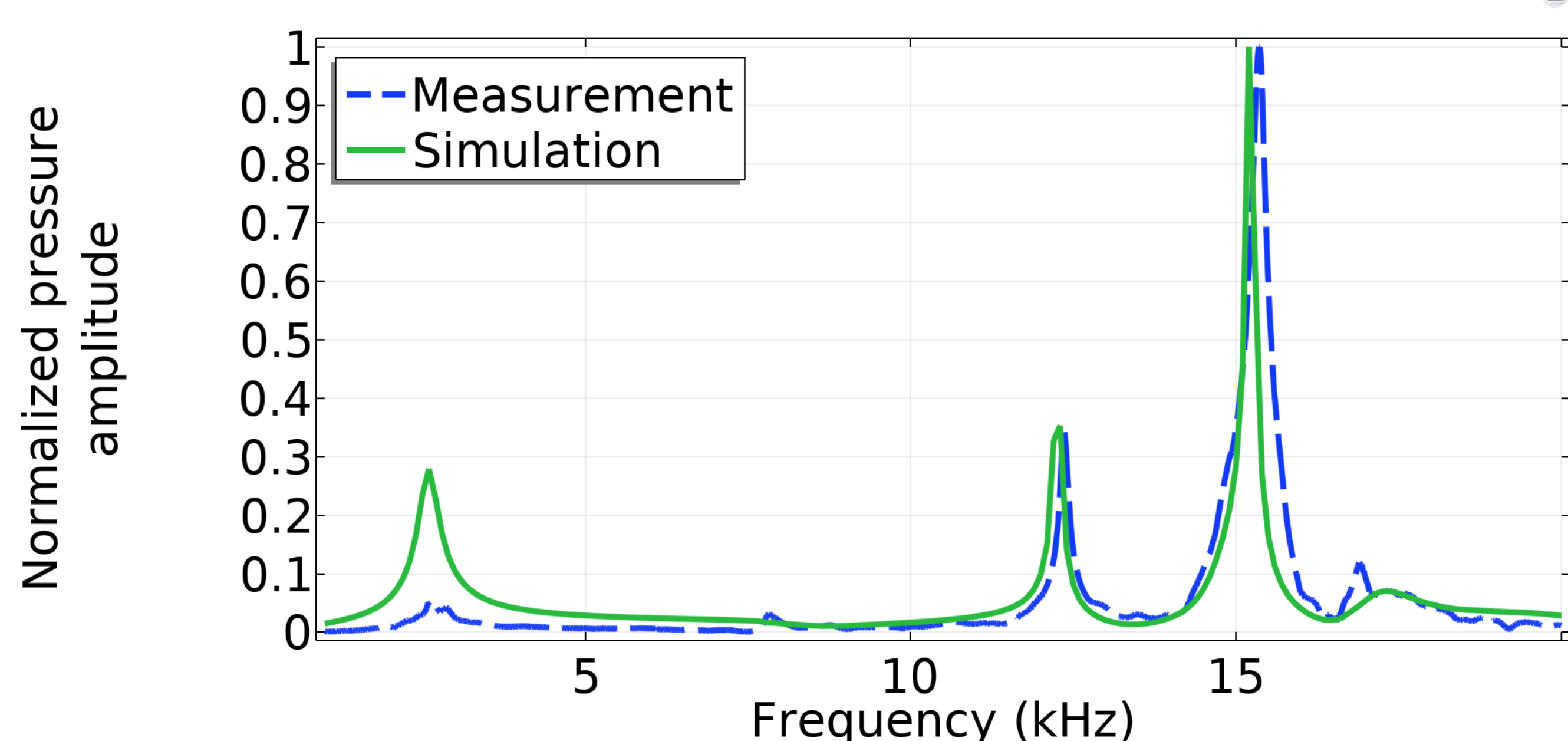


Figure 1. Comparison of the normalized simulated and measured photoacoustic spectra of the reference open resonator without longitudinal slits.

## Methodology

A three-dimensional finite element model of the open photoacoustic resonator was developed in COMSOL Multiphysics® 6.3 using the Pressure Acoustics, Frequency Domain interface. Eigenfrequency analysis was used to identify the relevant acoustic modes and locate the pressure nodal lines of the target mode, which determined the positions of the longitudinal slits.

The photoacoustic response was calculated in the frequency domain using a Gaussian volumetric heat source and Thermoviscous Boundary Layer Impedance to account for wall losses. The reference model was validated against experimental water-vapor measurements, followed by a parametric study of the slit width (0, 4, 8, and 12 mm).

## Results

The numerical model reproduced the main experimentally observed resonances of the reference resonator, including the two investigated modes at approximately 12.3 kHz and 15.4 kHz. The validated model was then used to study the slit-patterned design numerically.

The simulations show a mode-dependent effect: the target mode remains pronounced, while the competing mode is progressively suppressed as the slit width increases due to stronger coupling to the surrounding acoustic domain.

The results further suggest an optimal slit width that maximizes the target-to-competing-mode amplitude ratio.

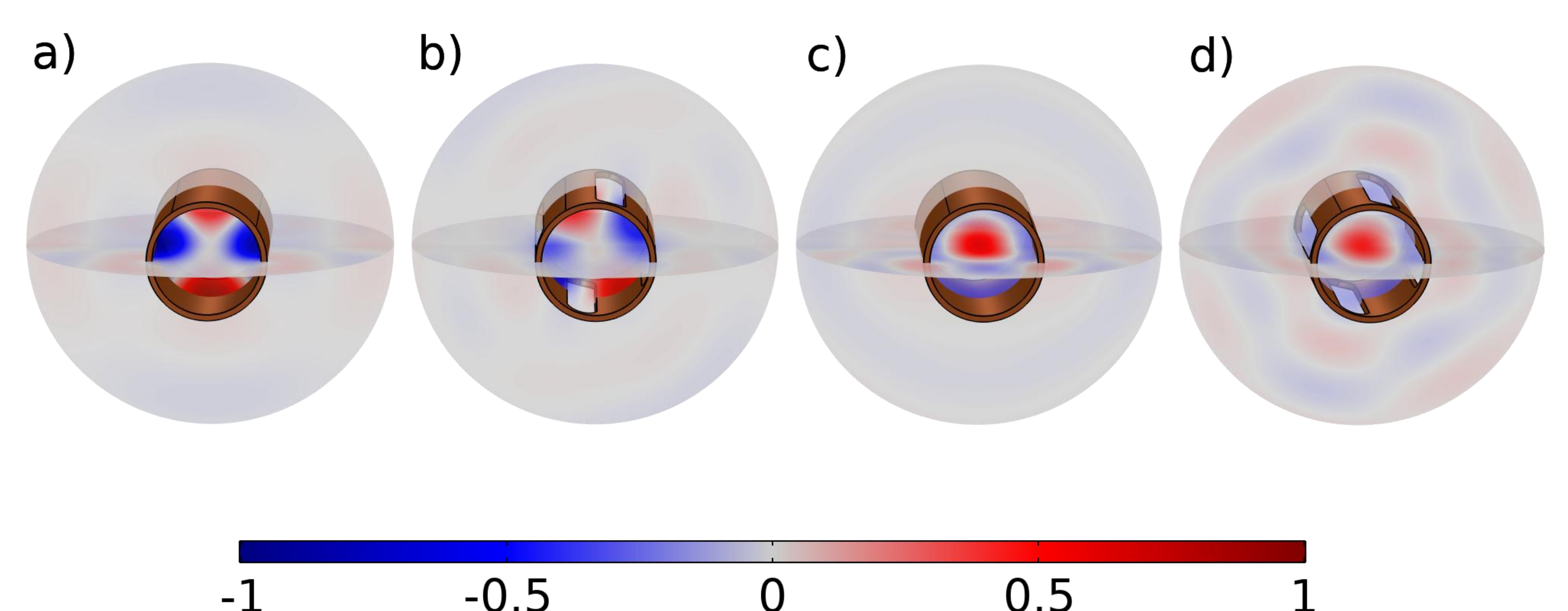


Figure 2. Normalized acoustic pressure distributions of the two investigated modes for the reference resonators (a, c) and the slit-patterned resonators with  $w_s = 8$  mm (b, d).

## REFERENCES

1. P. Ganguly and T. Somasundaram, *Proc. Indian Acad. Sci. Chem. Sci.* 98, 305-309 (1987).
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